Space Human Factors Engineering Research Benefits to Programs

Usability Testing and Analysis

December 2004

Provided by
Usability Testing and Analysis Facility

Selected Projects

- Glovebox Crew Restraints
- Life Sciences Glovebox (LSG) Crew Restraints
- Cupola Crew Restraints
- ISS Emergency Medical Procedures Assessments
- Emergency Exit Placards
- Wireless Crew Communication System
- Integrated Human Factors Evaluation Process

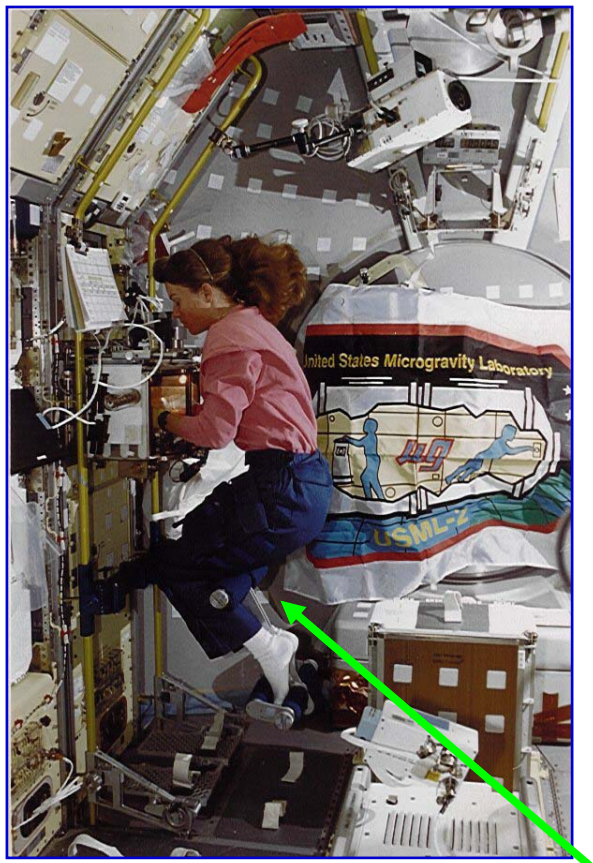
Crew Restraints: Shuttle Glovebox

- Research:
  - Code U Funded
- Application:
  - Assessed postures in microgravity in order to identity requirements for glovebox restraints (1996).
  - The Advanced Lower Body Extremities Restraint (ALBERT) was evaluated on STS-73 as a crew restraint for the Spacelab Glovebox for conducting material sciences experiments.
- Result:
  - ALBERT was found to work very well, and the results and restraint concept were provided as inputs to the Cupola crew restraint team.

Crew Restraints: Shuttle Glovebox (con't)

- As a result of a crewmember's injury from using a fixed on-orbit restraint with a glovebox over a long period of time, the Usability Testing and Analysis Facility (UTAF) was asked to identify requirements for glovebox restraints.
- The team performed a human factors assessment of postures in two microgravity evaluations aboard Shuttle, and provided an alternate solution which accommodated glovebox operations more efficiently.
- Results and restraint design requirements were delivered to the Cupola crew restraint requirements team.

Crew Restraints: Shuttle Glovebox (cont.)
Photographs of ALBERT from Orbit



ALBERT and its successor (FRED)

Crew Restraints: ISS Cupola

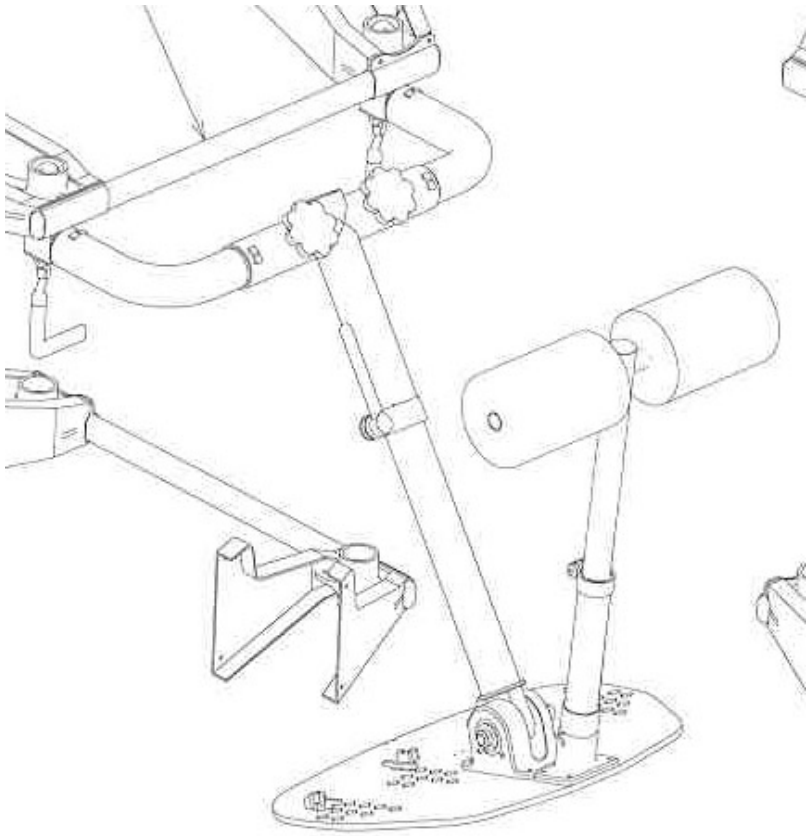
- Application:
  - Baseline requirements and validate the current design of the fixed angle between the knee-post and the platform
  - Verify how the different foot strap positions accommodate the neutral posture of different sizes of the crew (July 2002)

- Result:
  - Baselined requirements for Cupola Crew Restraints.
  - Determined the fixed angle between the footplate and knee post accommodates a 95th percentile American male and 5th percentile Japanese female with varying foot strap positions according to SSP50005C

Crew Restraints: ISS Cupola (cont.)
Development of Design Requirements

- The project team developed baselined requirements for the Cupola Crew Restraints.
  - The program office took the requirements and converted them into the cupola crew restraints requirements document.
- The team recommended an option with flexible restraints to be used in the Cupola.
  - The recommendation included designs with foot loops and foot loops with knee supports.
- The team continues to perform consultations with the program office in this area.

Crew Restraints: ISS Cupola (cont.)
Diagram of Crew Restraint



Crew Restraints: ISS Cupola (cont.)
Sample of Cupola Restraints Requirements

3.2.1.1 Restraint quality (A)

The CCR shall provide the crewmember with a stable and positive restraining feeling. A positive restraining feeling is defined as follows:

Considering the Human body rigid, the contact points shall be enough as to ensure the stability against rotation around any of the body axes;

Considering the Human body as rigid, the translation in any direction shall be prevented by at least one tie surface for each direction;

3.2.1.2 Control capability when restrained (I, A)

The CCR shall enable the crewmember to activate the joint controls, while restrained

3.2.1.3 Range of adjustment (A)

The crew restraint shall ensure the proper joint range of adjustment, to support the performance of selected CUPOLA tasks (nominal operational and maintenance tasks), by 5th percentile Japanese female to the 95th percentile American male.

3.2.1.4 Precision of joints (I, D)

The CCR's joints shall be adjustable with continues or discrete pitch, to ensure the required adjustability precision to accomplish the selected CUPOLA tasks.

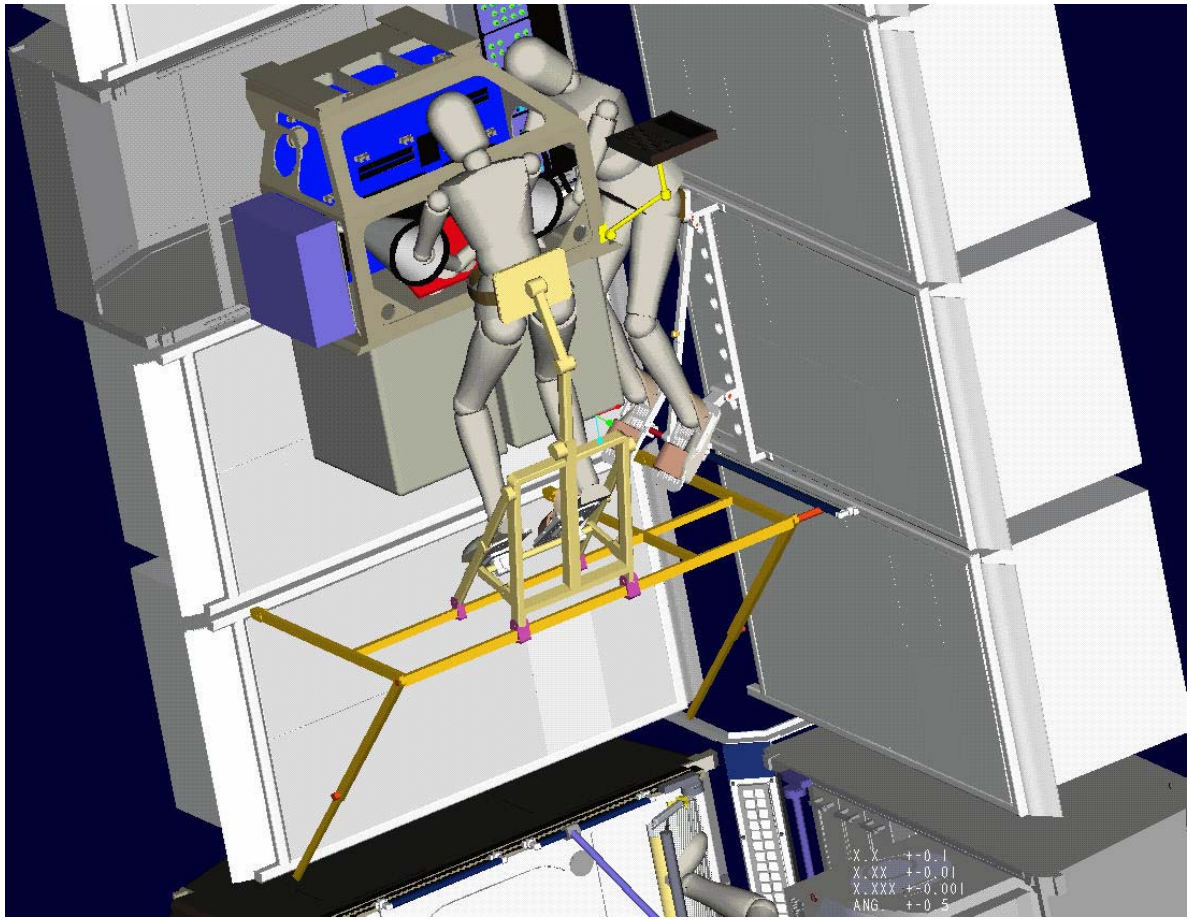
3.2.1.5 Soft padding (I)

The Cupola Crew Restraint shall provide soft pads, in order to ensure body comfort when restrained. These pads shall be present on the two horizontal beams of the knee support.

Crew Restraints: ISS Life Sciences Glovebox (LSG)

- Research:
  - Multipurpose Crew Restraints for Long Duration Space Flights TDP (2001 - 2004)
- Application:
  - Developed several candidate restraint designs based on preliminary requirements.
  - Conducted a series of human modeling and KC-135 microgravity evaluations on the candidate crew restraints for LSG. (March and June 2004)
- Result:
  - Identified key requirements for an LSG crew restraint.
  - Provided summary results to the LSG Critical Design Review in Japan.
  - The project team filled a gap in the program as they were the only team working on restraints for the Life Sciences Glovebox (LSG) .

Crew Restraints: Life Sciences Glovebox (cont.)



Life Sciences Glovebox Model demonstrating crew restraints.

Crew Restraints: Life Sciences Glovebox (cont.)

An evaluator aboard the KC-135 is in a restraint with shin and thigh supports.

ISS Emergency Medical Procedures Assessments: Checklist

- Research:
  - Emergency Medical Procedures on ISS: An Independent Human Factors Analysis and Review TDP (2001 - 2004).
- Application:
  - Conducted a document organization study of the on-orbit paper-based medical procedures (2001 - 2002)
  - Examined a Head-to-Toe Anatomical layout and an Alphabetical layout.
- Result:
  - Reorganizing to an Anatomical layout provided a more intuitive means of locating the appropriate diagnosis in the paper procedures.
  - Generated a change request, endorsed by flight surgeons, for the on-orbit medical procedures.

ISS Emergency Medical Procedures Assessments: Checklist (cont.)

- The goal was to determine human factors related shortfalls in ISS medical procedures, training, communications and equipment, and to recommend solutions that will improve crew performance in the event of a medical emergency.
- Assessments included:
  - Examined alternative reorganizations of the content of the paper-based ISS Medical Checklist to determine participants' ability to locate the diagnosis for several emergency medical scenarios.
  - Change Request to the document was prepared for submittal to the Space Medicine Control Board.

ISS Emergency Medical Procedures Assessments: Hardware

- Research:
  - Emergency Medical Procedures on ISS: An Independent Human Factors Analysis and Review TDP (2001 - 2004).
- Application:
  - Performed feasibility study for medical equipment pack redesigns.
  - Performed redesigns and evaluation of Respiratory Support Pack cue cards.
- Result:
  - Provided recommendations to Biomedical Systems personnel.
  - Provided recommendation for RSP cue card that are being pursued by Medical Operations team for implementation.
  - Identified requirements for future hardware and cue card redesigns.

ISS Emergency Medical Procedures Assessments: Hardware (cont.)

- Assessments of Hardware and Cue Cards
  - Performed a feasibility study for adding equipment to and identifying current problems with the Ambulatory Medical Pack (AMP) and Advanced Life Support Pack (ALSP).
    - Redesign recommendations have been provided to Biomedical Systems personnel and are being considered for upcoming redesign efforts.
  - Developed Respiratory Support Pack (RSP) Cue Card redesigns based on human factors principles, and evaluated them against the original in terms of completion time and errors.
    - Modifications produced marked improvements, and official changes are being pursued by the Med Ops Mission Support team.

RSP Cue Card	Average Time
Modified Original	6:59 min
Final Improved Format	3:50 min

Improvement of >3 min!

ISS Emergency Medical Procedures Assessments (cont.)
Respiratory Support Pack Cue Card Proposal

RESPIRATORY SUPPORT PACK (RSP) SETUP ALGORITHM

PCS Airlock: EC LSS O2 Lo P Sply Vlv
AL O2 Lo P Supply Vlv
and Open
Verify Actual Position OPEN.

RSP SETUP
1. Deploy RSP.
2. Remove metal distcap from Regulators supply hose and connect to CHeCS O2 supply hose. (**If CHeCS O2 supply unavailable, attach PBAs or shuttle O2 source).
3. Decide whether to use Low Flow Mask, Ambu Bag, or Intubate. (If intubating, attach patient valve to ILMA. Set RSP, BPM = 12, TV = 800).
4. Determine if additional treatment is required.

CONSCIOUS
O2 to Low Flow Mask
- BPM knob = dot
- Set Regulator flow rate = 12 L/min (CAUTION: use WHITE indicator line).
- √ O2 output by feeling for O2 flow from Regulator hosebarb
- Remove Low Flow Mask from RSP lid pocket and attach O2 tubing to Regulator hosebarb.
- If Low Flow Mask will be used for > 15 minutes, disconnect Autovent's supply hose from Regulator at Quick Disconnect (QD).

UNCONSCIOUS
O2 to Ambu Bag
- Turn Autovent BPM knob = dot
- Set Regulator flow rate to 12 L/min (CAUTION: use WHITE indicator line).
- √ O2 output by feeling for O2 flow from Regulator hosebarb with hand
- Remove Ambu Bag from ALSP and attach Ambu Bag O2 supply hose to Regulator hosebarb.
- Give one breath every 5 seconds with Ambu Bag and Mask (or remove mask and attach Ambu Bag to ILMA).
- If Ambu Bag will be used for > 15 minutes, disconnect Autovent's supply hose from Regulator at Quick Disconnect (QD).

INTUBATED
O2 to ILMA
- For use only in intubated patient
- Set Regulator flow rate = 0 L/min (CAUTION: use WHITE indicator line).
- Set Autovent BPM = 12 initially
- Set Autovent Tidal Volume = 800 ml
- √ For O2 flow by observing movement in green indicator on top of Patient Valve and by feeling for O2 flow
- Attach Patient Valve to ILMA.
- Secure O2 line as needed.

Will patient be transported back to Earth via shuttle?

YES

Patient Transported to Earth
- Remove Patient Extension Hose from RSP lid pocket and remove one Heat and Moisture Exchanger (HME) from RSP.
- Attach top (smaller end) of HME to L-shaped end of Extension Hose.
- Quickly disconnect Patient Valve from ET Tube, connect HME to ET Tube, and connect Extension Hose to Patient Valve.
- Retrieve Portable Breathing Apparatus (PBA).
- Obtain ISS Manned Systems Extension O2 line from Node or Airlock.
- Connect Extension O2 line to space shuttle O2 source: Panel M069M/M032M.
- Switch O2 supply from ISS CHeCS Rack to PBA.
- Move patient to shuttle.
- Switch O2 supply from Portable O2 bottle to shuttle O2 source via extension line.
- Secure patient in shuttle for return to Earth.
- Secure Autovent, Regulator, Patient Valve, and all flex lines near patient with Velcro straps in RSP lid.

NO

Patient NOT Transported to Earth
- If patient is to remain on Autovent > 15 min, insert HME between Patient Valve and ET Tube.
- Complete patient treatment per ISS Medical C/L or Surgeon instructions.
- Use an Alcohol Pad to clean used equipment.
- Restow RSP.

← Original Format

Proposed Format – addition of pictures and color cues →

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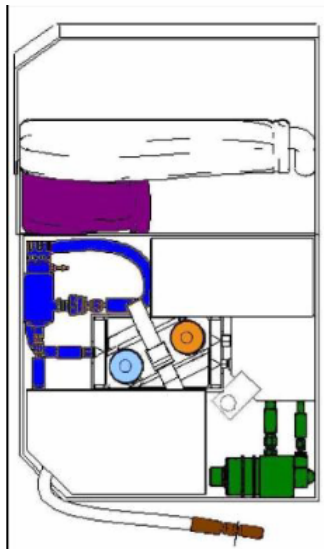
ISS MED-1ab/ALL/A



UNCONSCIOUS PATIENT

1. Deploy RSP, ALSP and Defibrillator
2. Pull red **metal cap** off of Regulator supply hose and connect to O2 supply (**If CHeCs is unavailable, use PBA)
3. Set Autovent **BPM knob** = dot (●)
4. Set **Regulator** flow rate = 12 (**CAUTION: Use WHITE indicator line)**
5. From ALSP, retrieve blue Ambu Bag and attach 02 Tubing to RSP **Regulator** hose barb
6. Place Ambu Bag on Patient and give 1 breath every 5 sec while preparing ILMA (in IK/A)
7. From IK/A, insert ILMA using ILMA cue card
8. Set **Regulator** flow rate = 0 (**CAUTION: Use WHITE indicator line)**
9. Set Autovent **BPM knob** =12
10. Set Autovent **Tidal Volume** = 800
11. √ **Patient Valve** for movement of green indicator on top and feel for 02 flow
12. Attach **Patient Valve** to ILMA
13. Contact Flight Surgeon
14. Monitor Patient

CONSCIOUS PATIENT

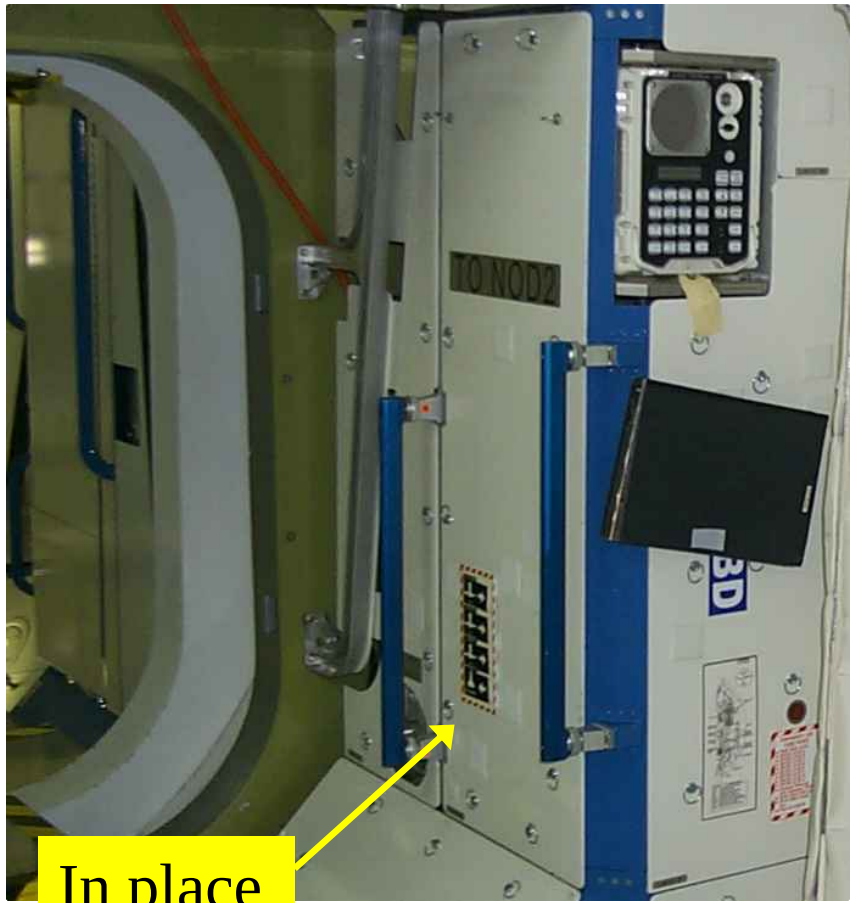
1. Deploy RSP, ALSP and Defibrillator
2. Pull red **metal cap** off of Regulator supply hose and connect to O2 supply (**If CHeCs is unavailable, use PBA)
3. Set Autovent **BPM knob** = dot (●)
4. Set **Regulator** flow rate = 12 (**CAUTION: Use WHITE indicator line)**
5. Remove **Low Flow Non-Rebreather Mask** from RSP lid pocket and attach 02 tubing to **Regulator** hose barb.
6. Put mask on Patient
7. Contact Flight Surgeon
8. Monitor Patient.

Emergency Exit Placards

- Application:
  - Conducted usability testing of alternative interface designs for emergency exit placards (2000 - 2002).

- Result:
  - Emergency Exit placards identified as best were installed in ISS on-orbit.
  - Demonstrated the need for placing additional markers showing escape routes on ISS.

Emergency Exit Placards (cont.)



Photographs of final design in place in the mockup.

Wireless Crew Communication System (In Progress)

- Research:
  - Wireless Crew Communication System TDP (2003 - 2005) – Habitability Design Center (HDC) and Usability Testing and Analysis Facility (UTAF) joint project with Engineering Directorate
- Application:
  - Define **functional, performance, and operational requirements** for wireless communication in the space environment using ISS as a testbed.
- Result:
  - Requirements for a wireless communication system drafted
  - Developing preliminary concepts and prototypes
  - ISS DTO planned

Wireless Crew Communication System

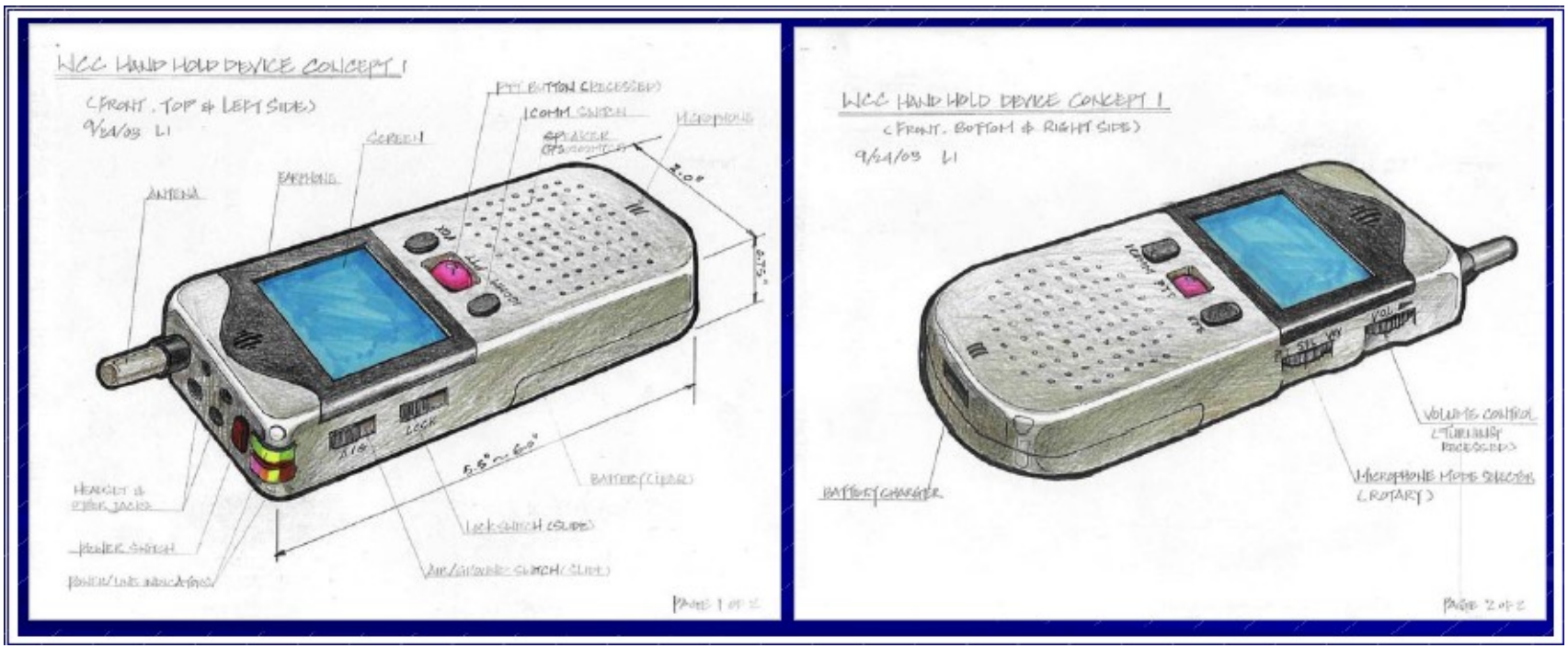
- Joint project with Engineering Directorate.

- Goal is to provide a wireless technology system that will be tested on ISS and benefit future exploration missions.
  - Initial system conceptual design based upon augmenting existing ISS audio system (eliminate cable to ISS Audio Terminal Unit (ATU)).
  - Focusing on using commercial industrial RF wireless standards.
  - Future technologies and designs are also being explored.

Wireless Crew Communication System (cont.)
Wireless Headset Control Unit Prototype

Prototype demonstration unit tested in the ISS System Integration Lab (ISIL) with Station audio system.

Wireless Crew Communication System (cont.)
Communication Unit Conceptual Design



Preliminary Concept of Hand-held Unit

Integrated Human Factors Evaluation Process (In Progress)

- Research:
  - Development and Demonstration of an Integrated, Independent Human Factors Evaluation Process for Space Payloads and Equipment TDP (2001 - 2004)
- Application:
  - Evaluated the human factors process for NASA equipment and payloads.
  - Gap analysis to compare NASA process with DOD & industry standard process.
- Result:
  - Root-cause analysis illustrating usability concerns in flown equipment/payloads
  - Definition of ideal human factors process for NASA environment in progress.
  - Web-based tool to support process under development.

Integrated Human Factors Evaluation Process

- Identified a Human Factors Evaluation (HFE) process flow to apply to hardware and software designs in new programs and existing Government Furnished Equipment (GFE) programs.
  - Adapted for Advanced Integration Metrics (AIM)
  - Plan to provide it for Human-Systems Integration Standards, Exploration, and ISS GFE projects
- In process of developing a computerized tool to guide hardware/software designers

Integrated Human Factors Evaluation Process (cont.)
Process Flow Diagram for AIM